Comparative Evaluation of Three Screening Methods for Detection of Hearing Loss in School Children

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Though screening for hearing loss is a widely adopted feature of the school health program, the methods to be employed are by no means a settled matter. A comparison study of screening technics reported here offers some answers—but not an unqualified answer—to this still unsettled problem.

✠ Since the introduction of the 4CA phonographic audiometer in 1926, the screening of school children for hearing loss has become an accepted and important facet of the total school health program. In more recent years, pure tone screening methods have been introduced in place of the spoken voice fading numbers test of the 4CA audiometer.[1-4] The latest available report on the extent of utilization of different methods of screening for hearing loss is for the school year 1947–1948.[5] At that time it was estimated that over one-half of the school population of the United States was covered by a screening program for hearing loss and that in about one-third of the programs pure tone screening was utilized alone.

An ideal case-finding program should select from a group of apparently well individuals the maximum number with a significant or potentially significant disability and the minimum number without such disability. The selection of school children with significant hearing loss from the total school population involves the use of a screening test, a diagnostic test, and a medical opinion. The screening test selects a portion of the school population for diagnostic testing. The diagnostic test selects a portion of the screening test failures for medical and educational appraisal. As a result of this appraisal, medical or educational recommendations, or both, are made for a portion of the diagnostic test failures. Both overselection and underselection may occur at any stage of this process of case finding. The screening test itself should be viewed as part of this total process and its results related to the results of diagnostic testing and educational and medical appraisal.

The cost of a screening test in terms of equipment, personnel, and time are additional factors which an agency choosing a given test must take into consideration. Of these factors, personnel and personnel time are the most expensive. Lay volunteers may be trained to administer and score the group voice fading numbers test, but they are not qualified to administer pure tone tests.

Most workers in the field of audiology have stated for some time that individual pure tone sweep check screening identifies more children with hearing loss for speech perception, as well as

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for tones above speech range, than group voice testing with fading numbers.[1-4] It also has been stated that the former method demands more time and is more expensive than the latter. Recently, Johnston has introduced two group screening technics known as the Massachusetts Hearing Test ("old" and "new") which were designed to reduce the time of pure tone screening.[6, 7] Johnston states that the newer group pure tone test has largely replaced the older one in Massachusetts at the present time.[8]

The study to be reported consists of a comparative evaluation of screening for hearing loss by three different technics—the individual sweep check, the "old" Massachusetts Hearing Test, and the group voice fading numbers test.

Material and Methods

For many years a well organized program of testing for hearing loss has operated in the public and nonpublic schools of Rochester, N. Y., under the joint sponsorship of the Board of Education and the Health Bureau. As is the case in many communities, school children from the third through seventh grades are tested every two years with the 4CA audiometer group fading numbers test. Children who fail the test are retested, and those failing the retest are given a pure tone threshold test and seen by a consultant otologist if it is necessary as indicated by the results.

Nine public schools with a third through seventh grade population of 2,818 were selected for study. This population formed a representative socioeconomic cross-section of the total third through seventh grade public school population. Of the population available for testing, 414 pupils were absent for all or part of the study period and were not included in the study group. The study group is composed of the remaining 2,404 pupils.

The screening procedures, diagnostic tests, and otologic appraisals were carried out within a period of two to three weeks for each of the nine school groups. They were performed in classrooms or other school rooms selected for low noise levels. A General Radio Company sound survey meter, Type 1555-A (with setting at the "A" position), utilized on several occasions, recorded ambient noise levels of 30–45 decibels in the testing areas.

The following screening procedures were utilized:

1. A group phonographic fading numbers test using a Western Electric 4CA audiometer with a set of 40 single 716-A magnetic receivers. This test was administered and scored by trained lay volunteers, essentially according to the method described in the Manual for a School Hearing Conservation Program.[2] A loss of nine or more S.U. in either ear was considered a failure. All children who failed this test were retested and rescored by the same method.

2. A group pure tone test, the "old" Massachusetts Hearing Test, using a Maico Model F-1 audiometer with a set of 40 Maico dynamic receivers. Double receivers, one live and one dummy, were utilized. They proved somewhat inconvenient with girls, since hair became entangled in them. This test was administered by an audiometric technician who had been given several weeks intensive individual training by one of the authors. The technic of administering and scoring the test was similar to that described by Johnston,[6] with the following exceptions: (1) the audiometer attenuator was set at 45 db for all frequencies; (2) signal tones were presented at 2,000, 500, 4,000, and 6,000 cps in that order with five "yes-no" options at each frequency; and (3) in scoring, children who marked more than two of the 20 "yes-no" options presented for either ear incorrectly were considered failures. Five master sheets, each with a different option pattern were used. All children who failed this test were retested and rescored by the same method.

3. An individual pure tone sweep check test using a Maico Model F-1 audiometer with double receivers. This test was administered by the same audiometric technician. At an intensity of 15 db, signal tones were presented twice at 1,000, 2,000, 4,000, 6,000, and 500 cps in that order. Children failing to hear any

Table 1—Results of Three Auditory Screening Procedures Applied to 2,404 Third Through Seventh Grade Children Rochester, N. Y., 1952–1953

	Number of Children	Screening Procedure		
		Group Phonograph	Group Pure Tone	Individual Sweep Check
Children Tested	2,404	2,404	2,404	2,404
Children with suspected hearing loss	465	167	211	262
Children whose suspected hearing loss was verified by threshold test	118	39	82	112
Children with medical or educational recommendations	74	31	53	71

one tone in either ear were considered as failures.

In each school, the administration of these three screening procedures was arranged in such a way that the audiometric technician was not aware of the identity of children who failed either of the two group screening tests until all children had been sweep check tested. All children who failed either of the group screening tests twice, or the sweep check once, were given a pure-tone threshold test by one of the authors using a Western Electric Model 6 BP audiometer with a single earphone. The technic described in the Manual for a School Hearing Conservation Program was followed.[2] Frequencies of 1,024, 2,048, 4,096, 6,144, 512, and 256 cps were presented in that order. Any child who had a loss in the poorer ear of more than 15 db at two frequencies, or more than 20 db at one frequency, was considered a failure. Such failures will be referred to hereafter as "verified failures" or children with "verified hearing loss."

All children with verified hearing loss were seen by an otologist.* The routine examination included inspection of nasal passages, pharynx, and tympanic membrane. Nasopharyngoscopy was not performed. Medical recommendations varying from requests for repeat observation to treatment for chronic otitis media were made by the otologist.

Educational recommendations, varying from preferred seating arrangements to speech reading instructions, were the joint decision of otologist and audiologist. They were made on the basis of the configuration of individual audiograms and the anticipation of possible future difficulty with hearing. In inspecting audiograms, particular attention was paid to losses at 512, 1,024, and 2,048 cps. Anticipation of future difficulty with hearing was based on the appraisal of past medical history.

Results

A total of 2,404 children received all three screening tests: group phonograph, group pure tone, and individual sweep check. As a result of this screening combination, 118 children (4.9 per cent) were determined to have a verified hearing loss. No one of the three screening procedures was able to select all 118 children; 39 children (33 per cent) were selected by the group phonograph screening procedure, 82 (69 per cent) by the group pure tone screening procedure, and 112 (95 per cent) by the individual sweep check screening

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Table 2—Deficiencies of Three Auditory Screening Procedures Applied to 2,404 Third Through Seventh Grade Children Rochester, N. Y., 1952–1953

	Screening Procedure		
	Group Phonograph	Group Pure Tone	Individual Sweep Check
Result of Screening Procedure			
Children tested	2,404	2,404	2,404
Children with suspected hearing loss	167	211	262
Deficiency of Screening Procedure			
Children with verified hearing loss missed by screening procedure	79	36	6
Children with no verified hearing loss, selected by screening procedure (overselection)	128	129	150
Children with verified hearing loss with no medical or educational recommendations	8	29	41

procedure. As a case finder, the individual sweep check test was the best of the three screening tests (Table 1).

Of the 118 children with verified hearing loss, medical or educational recommendations were made in the case of 74 (64 per cent). In the case of the remaining 44 children (36 per cent), the verified hearing loss was of such a nature as not to require medical or educational attention at the time of examination. No one of the three screening procedures was able to select all 74 children: 31 (42 per cent) were selected by the group phonograph screening procedure, 53 (72 per cent) by the group pure tone screening procedure, and 71 (96 per cent) by the individual sweep check screening procedure.

Although the individual sweep check was the best case finder of the three screening procedures, it selected more children with no hearing loss than either of the two group tests. However, the absolute number of children overselected by the sweep check, and thus needlessly given a pure tone threshold test, was not significantly in excess of the number of children overselected by either of the group tests (Table 2).

The same pattern of overselection is apparent in the medical and educational appraisals. Although the individual sweep check test was the best finder of significant cases, it selected the greatest number (41 children) with verified hearing loss of no apparent significance (Table 2). This overselection with its inherent overuse of personnel time must be balanced against superiority in selecting significant cases. Although there were 74 children with a verified hearing loss significant enough to require medical or educational recommendations, or both, 43 of these children (58 per cent) would not have received these recommendations if the group phonograph test had been the only screening procedure used. Similarly, if the group pure tone test had been the only screening procedure used, 21 of 74 children (28 per cent) would not have had medical or educational recommendations. However, if the individual sweep check had been the sole screening procedure used, only three children (4 per cent) would not have received medical or educational recommendations.

The screening procedures were timed

in the case of 1,721 children, about two-thirds of the total group. Actual time involved in setting up equipment, instructing the children, administering and correcting the test was measured. The time required to retest children who failed the specified group test was included in the calculation of total time, since the retest appears to be an essential step in the screening procedure. Of the three screening procedures, the group pure tone was the least time-consuming. The average time required for the various screening procedures was as follows: group phonograph—1.4 minutes per child; group pure tone —0.9 minutes per child; and individual sweep check—1.9 minutes per child.

Discussion

Interpretation of the significance of these results hinges on many factors: the standards of the audiometric testing procedures themselves, the criteria by which failures were judged, the accuracy with which the tests were performed, and the validity of the audiologic and otologic recommendations that were made.

Standards of audiometric testing and criteria for the selection of failures are not uniform. Watson and Tolan discuss some of these variations for the group phonograph test and point out the different combinations of frequencies used in pure tone testing.[4] The same authors recommend that sweep check screening be done at a constant 10 db level; whereas, the Committee on Conservation of Hearing of the American Academy of Ophthalmology and Otolaryngology recommends a level of 15 db.[2] The same committee recommends that failure to hear two or more frequencies in either ear on the sweep check be used as the criterion for referral for threshold testing; whereas, the programs in Maryland[9] and in Tennessee[10] utilize failure to hear one or more frequencies as the criterion.

As practiced in Massachusetts,[11] Michigan,[12] and Texas[13] the frequencies and number of "yes-no" options utilized for the "old" Massachusetts group pure tone test differed in each area. Modifications in the calibration of earphones and scoring of this test were made by DiCarlo and Gardner.[14]

Prior to setting up the present study, letters were written to several otologists and audiologists in an attempt to standardize both the testing frequencies and the failure criteria in some acceptable fashion. The advice received was conflicting.

Opinions concerning the clinical significance, potential reversibility, and methods of treating different types of hearing loss are also conflicting.[15, 16] In 1940 and 1942, Crowe, et al., reported a high percentage of children with high tone loss which cleared after irradiation of the hypertrophied lymphoid tissue.[17] However, adequate controls were not available at the time and the inferences of these early results have been questioned by Guild in a long-term follow-up study of the same children.[18] The significance of hypertrophied lymphoid tissue in the etiology of hearing loss in children is a controversial subject. It is reported as being present and requiring treatment in three-quarters of the children seen in one clinic[9] and one-fifth of those seen in a similar clinic.[19]

Although the diagnosis and significance of severe or moderate loss of hearing seems well standardized, the same cannot be said about minor degrees of hearing loss. This problem calls for longitudinal studies over a long period of time, correlating audiological, medical, and educational observations, before definitive statements can be made.

Because of these variations in technics, standards, and their interpretation,

values which measure or compare screening procedures are not easily fixed. Therefore, it may prove difficult to generalize the results of this study to the experience of others.

In third through seventh grade children, and practiced as described, pure tone technics were significantly better screening devices than the group fading numbers test. This was true both in terms of children with verified hearing loss and in terms of children who were recommended for special educational or medical consideration. Of the two pure tone tests, the individual sweep check was the better screening device but required considerably more time to perform.

The data concerning overselection lend weight to the frequently repeated admonition that the services of a qualified audiologist and otologist should be an integral part of the school conservation of hearing program. Only after adequate diagnostic procedures have been carried out, is it possible to make intelligent recommendations to school administrators or families.

When such procedures are included in a program, the choice of screening test becomes a joint professional and administrative decision particularized for that program. Furthermore new technics can be tried to see if they are adaptable and practical and the choice of screening test modified accordingly. The findings of studies such as that reported here may be of value in deciding the screening procedure to use under these circumstances.

Summary

1. Two thousand four hundred and four third through seventh grade pupils were screened for hearing loss by a group fading numbers test, a group pure tone test ("old" Massachusetts Hearing Test), and an individual sweep check test. The screening tests used are described in some detail.

2. Pupils failing either group test twice or the individual test once were given a pure tone threshold test. Pupils whose loss was verified by threshold testing were examined by an otologist.

3. One hundred and eighteen children were determined to have a verified hearing loss and medical or educational recommendations, or both were made for 74 of this group.

4. Pure tone technics were significantly better screening devices than the group fading numbers test. Of the two pure tone technics, the sweep check was the better case finder, but it required more than twice as much time to perform.

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